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Methods Used in Future Technology Analysis and its Selection: an application to VTOL transportation system

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Methods Used in Future Technology Analysis and its Selection: an application to VTOL transportation system [1]

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Abstract

Change is happening at an ever faster rate today, driven partly by technological changes leading to changes in all other areas of our lives. Today's global trends, uncertainties, and surprises have the potential to significantly change the way the world works tomorrow. Shaping the world we want to live in means being more aware of the future and seeking better approaches. In such increasingly uncertain environment, planning uncertainties force policy and decision makers to foster future-oriented technology analyses (FTA) by using foresight methodologies. FTA can help us react on the likely directions of technologies, manage the risks involved and shape technological trajectories in order to improve the long term benefits to society. Foresight methodologies seek to gather data and make sense of it so that people can think in different and new ways about the future. That data might be collected from humans or from the analysis of documents and artefacts, or both. The data might be analysed using qualitative or quantitative techniques, or both. To be used in strategy processes, however, data needs to be analysed, interpreted and used in ways that make sense to the organisation. There is no single set of methods used in all foresight activities. The methods used need to reflect the resources available and the objectives of the exercise. The choice of methods is critical, though it often appears to be based upon what is fashionable or which practitioners have experience in. The methods may be organised and interrelated in different ways. In other terms, the conduct of foresight analyses needs to be tailored to the type. The first thing to do is to choose the right methods which are most appropriate to the analysis and technology characteristics. One of the substantial advances has been a move away from a tool or method driven approach to one which relies on the selection of tools in accord with their appropriateness for the particular issue being examined, their relative strengths and limitations. Thus, the experience of observing so many developing nations attempting to conduct a Japanese style Delphi survey, with an extremely limited number of 'experts' and doubtful relevance of estimated technology realisation times to their economy, indicates the need to develop foresight appropriate to local conditions. Their use and contribution will be determined primarily by the values, structures and cultures of the organisations applying them. This paper will try to discuss the importance of future oriented technology analysis, in particularly technology foresight, and the question of how to select the best methodology among the existing ones. Although this paper intends to lay a framework and cover the tools used in technology futures analysis, in particularly emerging air transportation technologies, a full understanding of each of these tools is out of this paper. The conduct of analysis needs to be tailored to the type. The first thing to do is to choose the right tools which are most appropriate to the analysis and the technology characteristics. Thus, we have to set the criteria and figure out key aspects and factors for designing our research. In our case, the key aspects and factors are: it is a long term vision for 10-15 years later; an emerging air transportation mode; a socio- technological system of systems in transportation area which is composed of resources and stakeholders network, drivers and disruptors; and also normative, both qualitative and quantitative, national and global. The probably research tools that can be used are; agent based modelling, cost benefit analysis, scenarios, impact analysis, case study (Visioning), subjective judgement, roadmap, interviews, benefit visualization tool, literature reviews, and attending conferences.

Keywords: Foresight; air transportation; Methods; Scenarios; future oriented technology analysis

JEL codes: L9, O14, R41

Introduction

Organizations and society face many challenges in today's global world. They are experiencing rapid scientific and technological innovations. Products and process are becoming more complex. Time-to-market for products is shrinking and product life is shortening. Research and development (R&D) is expensive and reduced budgets are making it impossible for individual companies to independently develop all the technologies they might need to meet future market imperatives. Competition is global and fierce. Organization and society need to understand or anticipate the broad repercussions, costs and opportunities of that innovation to the best of its ability. In this context, organizations must use effective tools to plan their future. Technology foresight, as one of the most important tools, is a way to identify product or service needs, map them onto technology alternatives and develop plans to ensure the required technologies will be available, when needed. And it is also a way to analyse the adverse effects regarding the possibility of an unintentional negative impact on areas such as society, culture, and the environment.

Foresight is one of the most effective tools of building long term strategies and policies with the goal of promoting economic, political, and social sustainability. Foresight methodologies seek to gather data and make sense of it so that people can think in different and new ways about the future. That data might be collected from humans or from the analysis of documents and artefacts, or both. The data might be analysed using qualitative or quantitative techniques, or both. However, the challenge has been to develop appropriate method to guide the selection of foresight tools.

Hence, this paper will try to discuss the importance of future oriented technology analysis, in particularly technology foresight, and the question of how to select the best methodology among the existing ones. Although this paper intends to lay a framework and the tools used in technology futures analysis, in particularly emerging aviation technologies, a full understanding of each of these tools is out of this paper.

Why studying the future is important?

Most significant changes affecting organizations affect every part of society today. Countries, governments, businesses, and institutions continue to witness ever increasing surprise as complexity increases. Technical change and the appearance and diffusion of new technologies are having increasing impacts on the economy and society. The strategic importance of including technology in corporate planning has been acknowledged for a long time (Makridakis, 1996). The future is uncertain and unstable at all times, and technological change is also associated with a high degree of uncertainty. Therefore, government and companies should strive to predict the impacts which technology developments are likely to have on future society as well as business environment, and formulate adequate and consistent national innovation policy. Analyses of emerging technologies and their implications are vital to today's economies, societies, and companies. Such analyses inform critical choices ranging from the multinational level (e.g., the European Union) to the individual organization (e.g., a company). Decisions that need to be well-informed concern setting priorities for R&D efforts, understanding and managing the risks of technological innovation, exploiting intellectual property, and enhancing technological competitiveness of products, processes, and services (Beck, 1992).

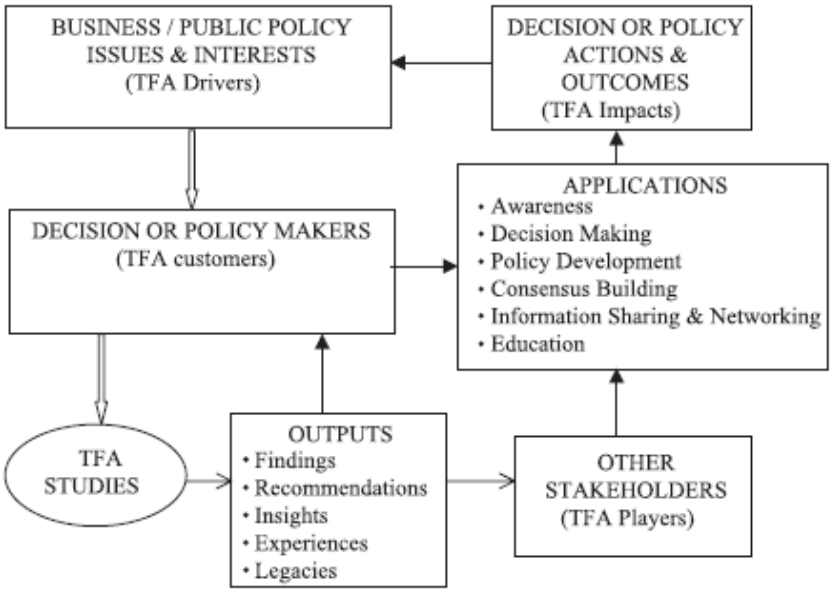
Information about technological developments can be of extreme value for companies deciding

on R&D priorities. One of the most effective instruments for it is Foresight. Strategic future-oriented activities are now commonly based on the methodology of Foresight. The outcome of foresight activities can be an enhanced market intelligence, enhances innovation capacity, enhanced competitive intelligence, the identification of promising new business fields and better strategic decision-making (Rohrbeck and Bade, 2012). Hence, nowadays, searching for new approaches to facilitate rapid development and a strengthen competitiveness of the national economy becomes an extremely significant goal. However, high levels of uncertainty and risk are among the main obstacles for decision making in the current economic and political situation (Beck, 1992).

Change is happening at an ever faster rate today, driven partly by technological changes leading to changes in all other areas of our lives, and by the increasing interdependence between countries and peoples today, as well as the decentralization of societies and institutions within countries (also furthered by information technologies today) (Porter, 2004). New surprises impact us far faster, and more profoundly, than we might think. Today's global trends, uncertainties, and surprises have the potential to significantly change the way the world works tomorrow. Shaping the world we want to live in means being more aware of the future and seeking better approaches.

This has made it necessary for governments, businesses, organizations, and people to better understand change and the future, since we will all be living and working in a future world that promises to be different from today in significant ways. When people better understand change, they also often see more opportunities for their lives and ways to better positively influence the future that is being created. For example, those who spot new trends through strategic foresight and exploit them early have competitive advantage over their less prepared rivals. Studies show that those that create, join quickly and then leave an emerging market just before it peaks are those achieving the best performance. How do they do that? The answer lies in their drive for a more agile and resilience-focused approach to being smart and forward-thinking. They have learned that continually searching for emerging trends, tipping points and weak signals is a vital intelligence tool to help them survive and thrive in an ever more competitive future (Jackson, 2013).

In an increasingly uncertain environment, planning uncertainties force policy and decision makers to foster future-oriented technology analyses (FTA). FTA can help us react on the likely directions of technologies, manage the risks involved and shape technological trajectories in order to improve the long term benefits to society. FTA encompasses the broad technology foresight and assessment studies of the public sector and the technology forecasting and intelligence studies in private industry (Porter, 2004). There are many overlapping forms of future-oriented technology analyses including technology intelligence, forecasting, road mapping, assessment, and foresight. ‘‘Technology foresight’’ refers to a systematic process to identify future technology developments and their interactions with society and the environment for the purpose of guiding actions designed to produce a more desirable future. ‘‘Technology forecasting’’ is the systematic process of describing the emergence, performance, features, or impacts of a technology at some time in the future. ‘‘Technology assessment’’ is concerned with the impacts of technology. The strategic components of FTA appears in a structured framework of the major forces and elements affecting the FTA process and arising from FTA activities (Porter, 2004).



A Future Technology Analysis Framework (Porter, 2004)

Future oriented technology analysis is widely accepted as to be problem oriented research. This means a strategy should be developed to contribute to the solution of a social, political, ecological problem referring to technology. Selecting the "right" methods to do FTA is the main task for FTA researchers. Since this question has to be answered before a real project starts, one has to develop a set of criteria which the decision concerning the "right" method could be based upon. Decker argues that the selection of the "right" methods can be justified on three main aspects: The actual political, social or ecological situation, the identified goals a potential project should strive for, and the individual institutional setting. Moreover, general quality criteria of "good practice" to do FTA have to be considered (Decker, 2004).

The role of foresight in technology strategy

Technology foresight has been formally defined as the "systematic process to identify future technology developments and their interactions with society and the environment for the purpose of guiding actions designed to produce a more desirable future" (Santos, 2013). Foresight is one of the most effective tools of building long term strategies and policies with the goal of promoting economic, political, and social sustainability. Foresight activities provides the vision and the direction for S&T area and aim at revealing the most promising S&T and innovation development areas and becomes a main part of government S&T policy. This approach gives the opportunity to estimate how S&T development could contribute to boosting the competitiveness of the country and meeting the major socio-economic challenges (Vihnevsky, 2013). Since the early 1990s, technology foresights have played an increasingly important role in the innovation and technology policy of various actors. The enormous increase in technological know-how, the growing complexity of technologies and the necessity to efficiently utilize scarce resources to boost innovation are only a few of the reasons. Even more, shortening innovation cycles accompanied by high competitive pressure add to the growing demand for knowledge about the future, which is required for the strategic decision making of governments, international organizations and companies (Zweck, 2014).

Futures research (or future studies) is not a scientific discipline, but utilizes information from all of the sciences. Foresight is, in fact, a process of studying the future. In other words, it is the study of potential change. It can be applied either to technology, or to social relations systems (Moniz, 2006). A value of futures research is not discovering new factual knowledge as the scientific disciplines, but producing perceptions, visions and insights to that body of knowledge. In this sense, the interest for policy (in the field of science, or technology development, economy, employment structures or even public administration) decision-making is evident. The future analysis, in scientific terms, is not simply economic projections or sociological analysis, or even technological forecasting. Instead, it is a multi-disciplinary examination of change, in order to discover the interacting dynamics that are creating the next generation (Moniz, 2006). And, scholars agree in one point that technology foresight is a key process that generates useful information as an aid to decision making, and an effective tool to support the formulation of technology strategies (Santos, 2013).

Therefore, foresight demands attention to socio-economic contextual factors interacting with emerging technical capabilities that affect commercial products and services. While the importance of analyzing potential future technologies remains unquestionable, this analysis should be accompanied with investigations on market trends as well, in order to provide a richer picture of the linkages between future technologies, products, services and their future market potential. It is also less concerned with accuracy and predictability and seeks to create shared visions of the future that stakeholders are willing to endorse by the actions they choose to take today. The main contribution of technology foresight lies not in predicting the future, but rather in preparing managers to handle the future. Therefore, practices and techniques should aim at enhancing an organization's capability to detect changes in the environment, seize these changes and re-adapt its tangible and intangible assets to align with the external environment (Santos, 2013). Also Miles (2008) argues that foresight should include the following elements:

- structured anticipation of needs (technology, society, etc.),
- interaction of different stakeholders in contrast to forecasting which uses only experts,
- creation of a network of stakeholders with different expertise,
- a strategic vision of the network of stakeholders,
- visions of the future, not utopia, that provide explicit implications for action and decision,
- communications among different disciplines, able to explain complex phenomena.
- In the context of policy-making, the most important intentions of foresight exercises are to
- find out changes in consumer preferences and to detect new technological opportunities,
- identify a choice of technological opportunities, set policy, e.g. regulatory, priorities and assess potential impacts and chances,
- discuss desirable and undesirable futures,

- prospect the potential impacts of current research, technology and regulatory policy,

- focus selectively on economic, technological, social and ecological areas as well as to start monitoring and detailed research in these fields (Blind, 2008). And, Leigh argues that there are five ways in which strategic foresight teams can contribute to more innovative government:

- anticipating emerging issues,

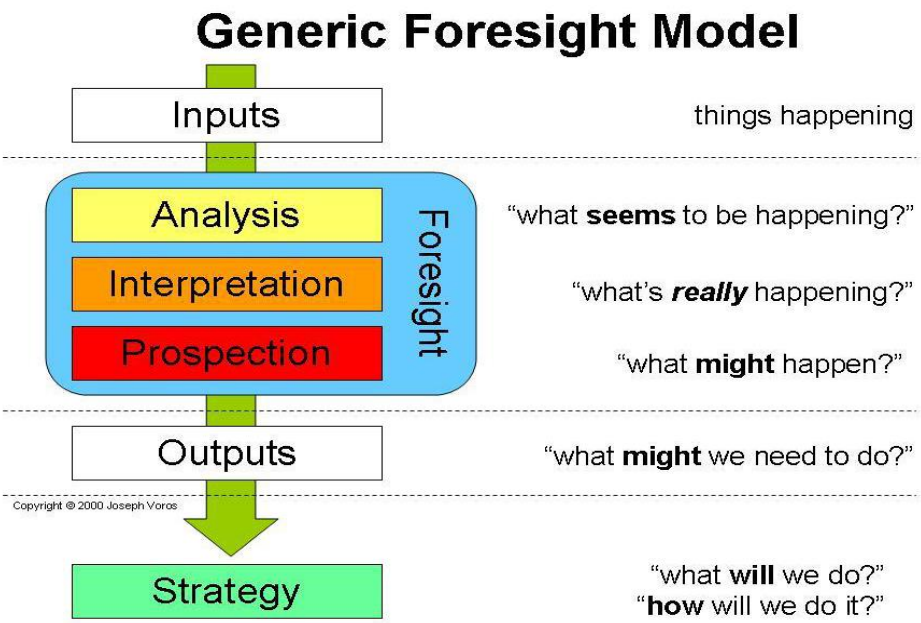
- identifying unanticipated consequences,

- getting a sense of the big picture,

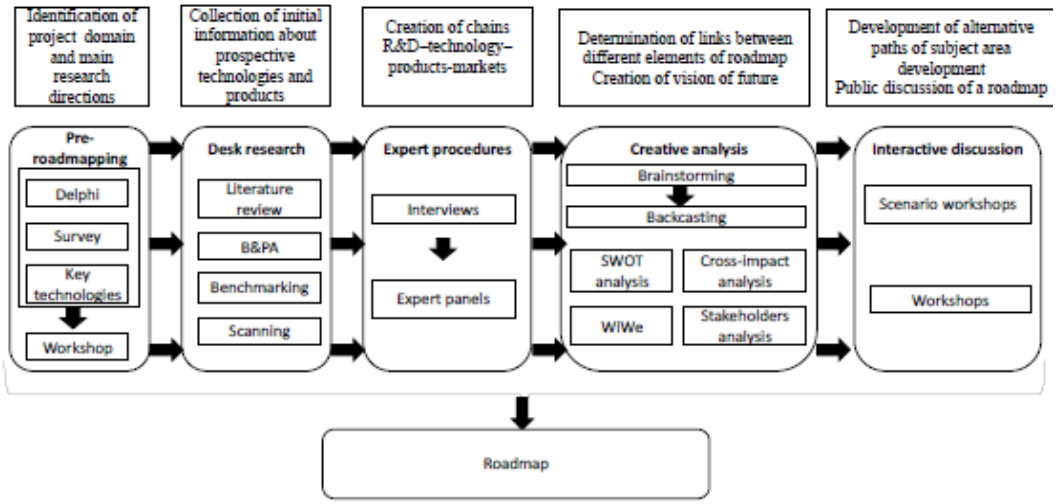
- drawing on a wide range of information sources,

- involving the public (Leigh, 2003).

Foresight methodologies seek to gather data and make sense of it so that people can think in different and new ways about the future. That data might be collected from humans or from the analysis of documents and artefacts, or both. The data might be analysed using qualitative or quantitative techniques, or both. To be used in strategy processes, however, data needs to be analysed, interpreted and used in ways that make sense to the organisation. Information emerging from this analysis and interpretation allows an organisation to better understand its past and present, which provides the basis for using foresight methods to explore potential futures. Foresight methods are used to inform the thinking processes of staff in an organisation so that better and wiser decisions can be made about future strategy. They seek to develop a longer term framework, outside the business-as-usual constraints of the present, within which thinking about potential strategic options can occur. They provide a way of making sense of an uncertain and complex future environment, using as wide a frame as possible, so that meaning might emerge to inform decision making (Conway, 2007).

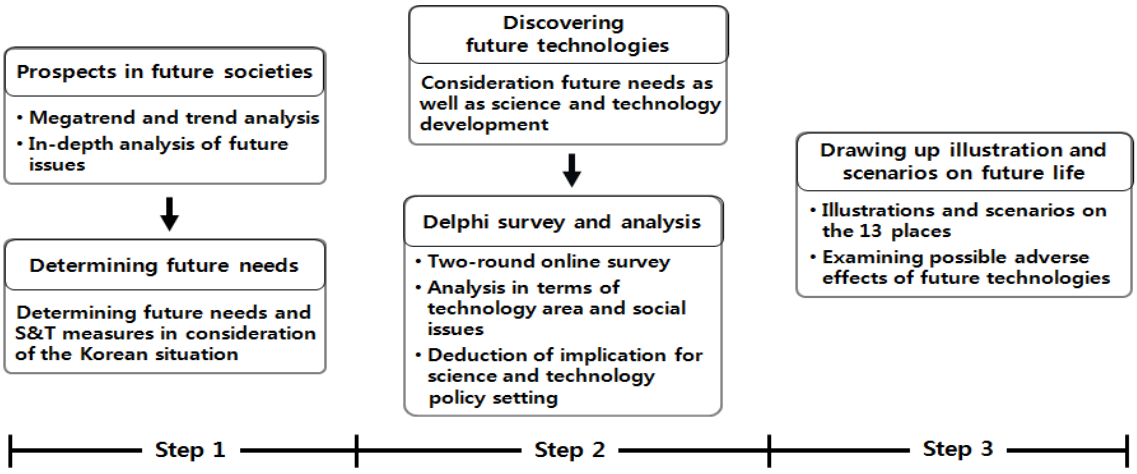


In strategy, it is about expanding the perceptions of the options available to an organisation so that new and sustainable options can be discovered and considered. As such, foresight in organisations is about expanding the mindsets of people, by questioning long held assumptions and beliefs that underpin present strategy. Careful choice of methodologies is required so that people understand the process that they are experiencing, what outcomes are expected, and how those outcomes will be used. The difficulties with implementing outcomes arising from the use of foresight methodologies are not different from any traditional strategy process. It is possible, though, that the more the foresight methodology has taken into account the organisational context in its broadest, most integral sense, the more chance there might be of successful implementation of subsequent strategy decisions (Conway, 2007). The use of particular methodologies depends on two factors: the tradition in which a practitioner works, and the organisational context in which the work has to be carried out. Every practitioner will have preferred methodologies, but the choice of which to use must ultimately depend on what is appropriate for the organisation. (Conway, 2007)



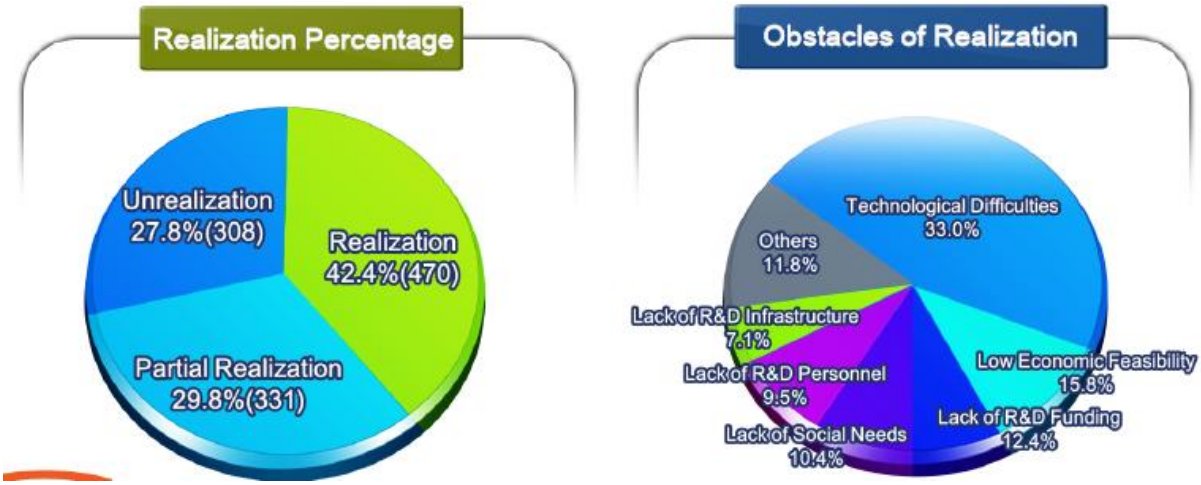
A sample of Foresight framework for the sphere of new materials (Vishvnevskiy, 2013)

One example is Technology Foresight in Korea. The primary purpose is to predict the development of S&T and reflect the results in policies related to S&T. Foresight activities provide the vision and direction for S&T area. They identify new technology that may have high potential for growth of national wealth and betterment of quality of human life.



The fourth Korean Technology Foresight framework

Another thing to consider is to conduct an evaluation of realization rate of former technology foresights to provide feedback to contribute careful selection of methodologies. For example, the 1st Korean Technology Foresight was conducted in 1993-1994 on 1109 technologies that were predicted to be realized by 2010. An evaluation of realization rate of future technologies of 1st Technology Foresight was conducted. The realization percentage was 42.4 % (72.2 % including partial realization).



The first Korean Technology Foresight realization percentage (Source: Korea Institute of S&T Evaluation and Planning)

Foresight studies are also used to understand technology topics which have priority and changes over time. An article summarizes the experience of Technology Foresight studies carried out since 2004 in China, Japan, France, UK, USA and the EU. Despite the many differences observed between the studies, it is noted some significant common issues. All the foresight studies give priority to energy; health, medicine, nutrition; biotechnology / life sciences; nano- and micro systems technology; and also to ICT, electronics, manufacturing, process and material technology, environment, defence and space technologies. Herewith, all the technology forecasts assumed that progression in sustainability/environment and ICT was a prerequisite for progress in other areas (Zweck, 2014).

Topic	2004–2013
Energy	↗
Biotechnologies and Life Sciences	↗
Health (including Medical Engineering) and Nutrition	↗
Nano- and Microsystem Technology	↗
Sustainability and Environment	↗
Optical Technologies	↗
Aerospace Engineering	↗
Production and Process Engineering	→
Construction and Housing	→
Defence and Security	→
Material Science	↘
Electronics	↘
Transport and Traffic, Logistics	↘
Marine Technology and Shipping	↘
Services	↘
Information and Communication Technology	↘

Source: VDI Technologiezentrum.

Change in topical relevance in Technology Foresight studies (Zweck, 2014)

How are foresight methods selected?

This section's objective is to discuss selection of right methodological approaches, and to understand which criteria can be used to select among methods. The challenge has been to develop appropriate approach to guide the selection of foresight tools. But there is a marked shortage of clear guidance as to when, where and how particular methods can be useful, what their costs and benefits are. Different forecasting methods naturally will not offer the same outputs, even when they are drawing on evidence and perspectives that should be yielding broadly similar results.

As argued in Miles and Keenan (2002), foresight is a set of approaches to bringing longer-term considerations into decision-making, with the process of engaging informed stakeholders in analysis and dialogue. These approaches are:

- policy-making approaches adopt a longer-term perspective in the form of strategic planning, allowing flexibility and preparedness to deal with uncertainty, disruptive events and innovations,
- participative approaches involve interaction of wider ranges of stakeholders and experts in envisioning the future,
- prospective (forward-looking) approaches involve traditional forecasting efforts, using systematic methods to explore future dynamics, enabling development of coping strategies.

The purposes of used methods are:

- investigation of the long-term (e.g. trend extrapolation, simulation, mega trend analysis, etc.),
- opinion elicitation (e.g. interviews, surveys, Delphi, etc.),
- deliberation (e.g. working groups and panels, workshops, conferences, public forums, etc.),
- creation and envisioning of futures (e.g. scenarios, essay-writing, science fiction, etc.),
- determination of courses of action (e.g. technology road mapping, multi criteria analysis, various prioritisation techniques, etc.).

According to EFMN (European Foresight Monitoring Network) analysis, the exercises use, on average, 4-7 different methods as part of an overall methodology (Popper, 2007). Porter suggests that we consider technology foresight as a multidimensional activity. Thus, the conduct of foresight analyses needs to be tailored to the type. The first thing to do is to choose the right method which is most appropriate to the analysis and technology characteristics such as disruptive versus

incremental technology. It would depend on uncertainty surrounding technology development, data availability, technology difficulties, funding for R&D. It is evident that the choice of the application of a methodology depends in a first place from the topic, but especially on the objectives of a study (Ciarli, 2013). The main findings of a study are that FTA quantitative techniques are extremely diverse, and that the choice of FTA techniques appropriate for a given foresight exercise depends on the characteristics of specific cases. Hence, the quality of an FTA does not depend on an `ideal' or intrinsic quality of the FTA technique itself, but rather on achieving a satisfactory match between the goals of the foresight exercise and the particular FTA technique that will full them (Ciarli, 2013).

One of the substantial advances has been a move away from a tool or method driven approach to one which relies on the selection of tools in accord with their appropriateness for the particular issue being examined, their relative strengths and limitations. Thus, the experience of observing so many developing nations attempting to conduct a Japanese style Delphi survey, with an extremely limited number of ‘experts’ and doubtful relevance of estimated technology realisation times to their economy, indicates the need to develop foresight appropriate to local conditions. Their use and contribution will be determined primarily by the values, structures and cultures of the organisations applying them (Tegart, 2004).

Method Families	Sample Methods
Creativity Approaches	TRIZ, Future workshops, Visioning
Monitoring and Intelligence	Technology Watch, Tech Mining
Descriptive	Bibliometrics, Impact checklists, State of the Future Index, Multiple Perspectives Assessment
Matrices	Analogies, Morphological analysis, Cross-Impact analysis,
Statistical Analyses	Risk Analyses, Correlations
Trend Analyses	Growth curve modelling, Leading Indicators, Envelope Curves, Long wave models
Expert Opinion	Survey, Delphi, Focus groups, Participatory approaches
Modelling and Simulation	Innovation systems descriptions, complex adaptive systems modelling, chaotic regimes modelling, technology diffusion or substitution analyses, input-output modelling, agent-based modelling
Logical/Casual Analyses	Requirements analysis, institutional analyses, stakeholder analysis, social impact assessment, mitigation strategising, sustainability analysis, action analyses (policy assessment), relevance trees, futures wheel
Roadmap	Back casting, Technology/Product Road mapping, Science Mapping
Scenarios	Scenario Management, Quantitatively based scenarios
Valuing/Decision Aiding/Economic Analyses	Cost-Benefit Analysis (CBA), Analytical Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Multi-criteria Decision Analyses
Combinations	Scenario-Simulation (gaming), Trend Impact Analysis

Future-oriented Technology Analysis Methods (Porter, 2010)

The ‘Technology Futures Analysis (TFA) Methods Working Group approaches this issue through consideration of the scoping of the TFA. Scoping lays out the playing field of the activity, where the study applies, at what level of detail, and which issues are central. Secondly, scoping should consider the process by which the study is carried out (the actions to be taken in performing a TFA: the ‘how’ to do it). They identify three content issues; time horizon, geographical extent and level of detail (micro/meso/macro). There are also eight process issues; participants (number, nature), decision processes (operational, strategic, visionary), study duration, available resources, methods, organisation, communication flows and presentation of findings. Together, these represent an essentially comprehensive set of criteria to guide the selection and application of forecast and foresight tools. In addition to improved approaches to the selection of forecast/foresight tools, the recognition of the different characteristics of the various tools has led increasingly to the use of multiple tools in a staged process (Tegart, 2004).

Issues	**Dimension**	**State Values**			
Content	Motivation	Extrapolative	Normative		
	Drivers	Science(Research)	Technology	Innovation	Context
	Scope	Single Topic or Technologies	Multiple Technologies	Wide-Ranging Planning	
	Locus	Institution	Sector	Nation/Region	Global
	Time Horizon	Short (1-2 year)	Mid-Range (3-10 year)	Long (15+ years)	
	Purpose	Informational	Action-oriented		
Process	Target Users	Few, Knowledgeable	Diverse		
	Participation	Narrow mix; closed Process	Intermediate	Diverse mix; representative process	
	Study Duration	Day(s)	Month(s)	Year(s)	

Technology Foresight Typology (Porter, 2010)

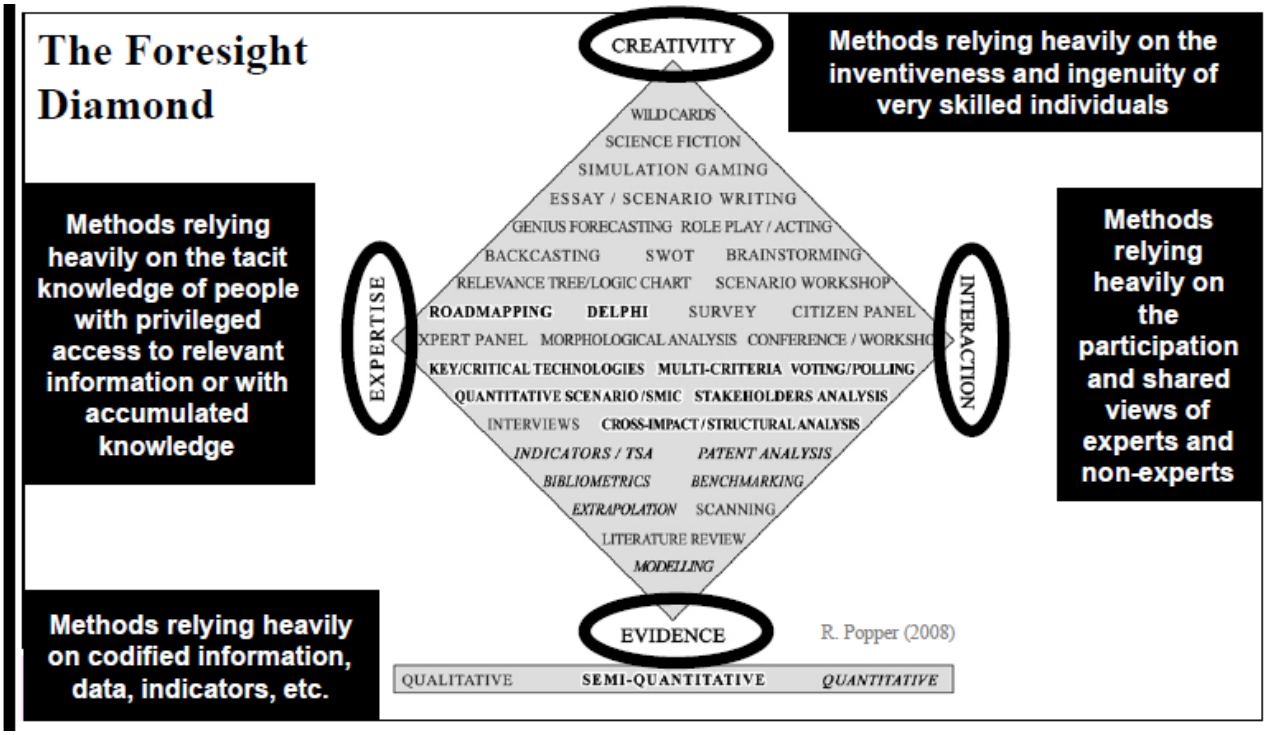
Quantitative or qualitative methods may be used to produce normative and exploratory forecasts. Thus, all of the methods that have been considered in this series can be classed as either quantitative or qualitative and as applicable to normative or exploratory forecasting (or both). Some people have argued that any technique can be applied to normative as well as exploratory forecasting; it's simply a matter of how the technique is applied. The matrix presented below serves as a simple taxonomy of the methods of futures research and indicates the primary usage in the field (Gordon, 2004).

	Quantitative	Qualitative	Normative	Exploratory
Agent Modelling		X		X
Bibliometrics	X			X
Causal Layered Analysis		X		X
Cross-Impact Analysis	X			X
Decision Modelling	X			X
Delphi Techniques		X	X	X
Econometrics and Statistical Modelling	X			X
Environmental Scanning		X		X
Field Anomaly Relaxation		X		X
Futures Wheel		X	X	X
Genius Forecasting, Vision, and Intuition		X	X	X
Interactive Scenarios		X	X	X
Multiple Perspective		X	X	X
Participatory Methods		X	X	
Relevance Trees and Morphological Analysis		X	X	
Road Mapping		X	X	X
Scenarios	X	X	X	X
Simulation-Gaming		X		X
State of the Future Index	X	X	X	X
Structural Analysis	X	X		X
Systems Modelling	X			X
Technological Sequence Analysis		X	X	
Text Mining		X	X	X
Trend Impact Analysis	X			X

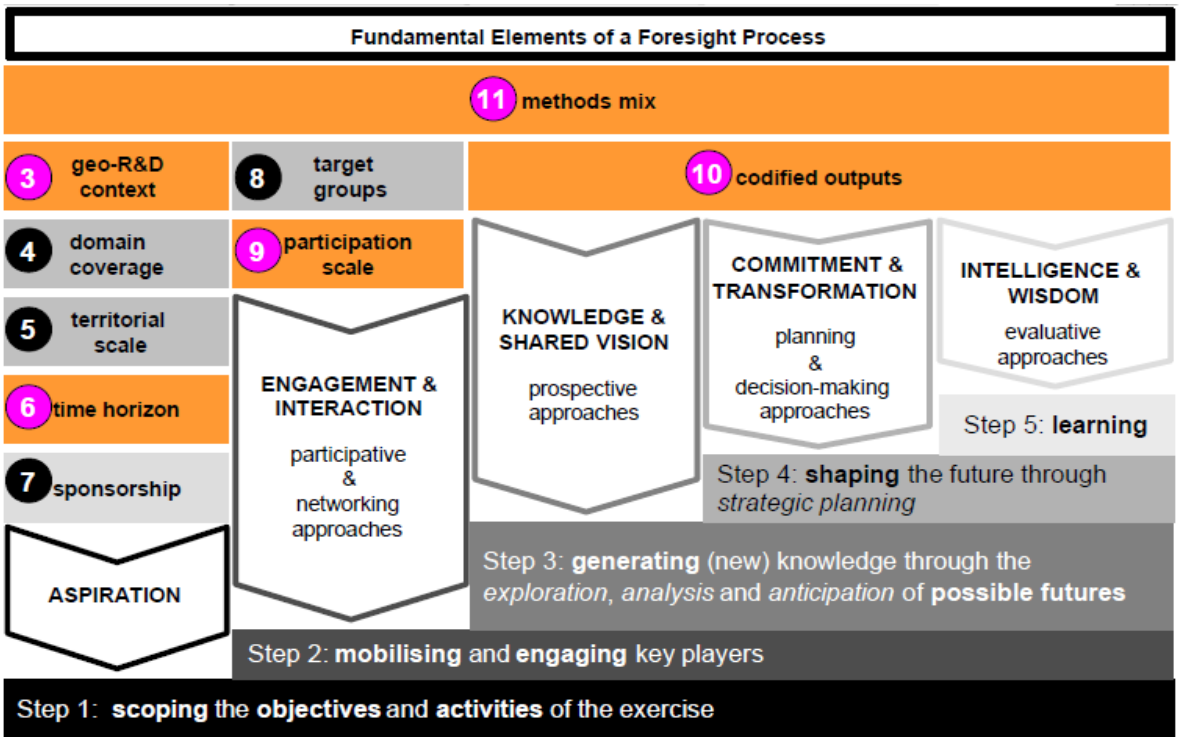
The methods of Future Research Analysis (Gordon, 2004)

Qualitative	Quantitative	Semi-quantitative
Methods **providing meaning to events and perceptions.** Such interpretations tend to be based on subjectivity or creativity often difficult to corroborate (e.g. brainstorming, interviews)	Methods **measuring variables and apply statistical analyses, using or generating (hopefully) reliable and valid data** (e.g. economic indicators)	Methods which **apply mathematical principles to quantify subjectivity, rational judgements and viewpoints of experts and commentators** (i.e. weighting opinions)
1.Backcasting 2.Brainstorming 3.Citizens panels 4.Conferences/workshops 5.Essays /Scenario writing 6.Expert panels 7.Genius forecasting 8.Interviews 9.Literature review 10.Morphological analysis 11.Relevance trees /logic charts 12.Role play / Acting 13.Scanning 14.Scenario /Scenario workshops 15.Science fictioning (SF) 16.Simulation gaming 17.Surveys 18.SWOT analysis 19.Weak signals /Wildcards	20. Benchmarking 21. Bibliometrics 22. Indicators / time series analysis 23. Modelling 24. Patent analysis 25. Trend extrapolation / impact analysis	26. Cross-impact / structural analysis 27. Delphi 28. Key / Critical technologies 29. Multi-criteria analysis 30. Polling / Voting 31. Quantitative scenarios / SMIC 32. Roadmapping 33. Stakeholder analysis Source: Popper (2008)

Classifying methods by their nature (Popper, 2008)



How is selection influenced by methods` capabilities (Popper, 2008)



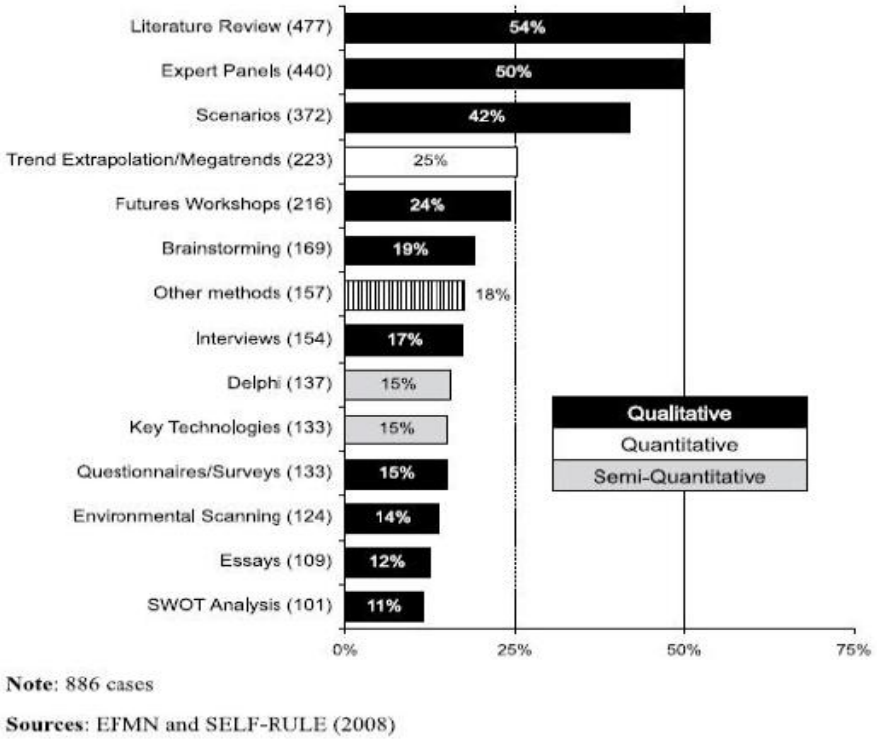
How is selection influenced by their elements (Popper, 2008)

Attributes of foresight methods		Influence on methods selection			
		Low	Moderate	High	V-High
Intrinsic nature (i.e. qualitative, quantitative or semi-quantitative)					••••
Capability to gather and process evidence, expertise, creativity or interaction				•••	
Elements of a foresight process		**Influence on methods selection**			
		Low	Moderate	High	V-High
Pre-Foresight phase	Geo-R&D context			•••	
	Domain coverage	•			
	Territorial scale		••		
	Time horizon		••		
	Sponsorship		••		
Recruitment phase	Target groups	•			
	Participation scale		••		
Generation, Action and Renewal phases	Codified outputs			•••	
	Methods Mix				••••

Factors influencing the selection of foresight methods (Popper, 2008)

On the other hand, the internet has made participatory approaches among geographically dispersed people practical. Wireless Internet, knowledge visualization software, and improved computer translation will allow more international foresight activities to build collective intelligence through participatory feedback systems. Forty years ago, computers were not an important factor in futures research. Delphi was done with pencil and paper in 1963, and sent through the mail. If current trends continue, forty years from now nearly all futures methods will be conducted in software, through networks, with diverse and changing sets of people, continually cross-referencing data and monitoring decisions. Within twenty-five years, dramatic increases in collective human-machine intelligence were judged to be plausible by the majority of an international science and technology

panel. Hence, the image of a few bright people, using a few interesting methods to forecast the future, may be replaced by the image of many people interacting with many combinations of methods to shape the future by blurring the distinctions between research and decision-making (Gordon, 2004).



Most commonly used methods (Popper, 2008)

Criteria for tool selection in exercises: the case of technology assessment of VTOL personal and mass air vehicles

We consider Technology Assessment as a multidimensional activity. Technology Assessment evaluates the positive and negative impact caused by new technology on areas such as economy, society, environment, and technology itself. Thus, there are many techniques that are used during a technology assessment. These techniques may have been borrowed from foresight analysis, economic analysis, operations research, or other fields, and you are encouraged to use appropriate techniques from other fields, regardless of whether you have seen them used in a technology assessment before. Here are the most common foresight tools which are used for Technology Assessment (Porter, 1980):

1. Risk Analysis
2. Brainstorming
3. Interpretive Structural Modelling

4. Trend Extrapolation
5. Opinion Measurement
6. Scenarios
7. Checklists
8. Relevance Trees
9. Cross-Effect Matrices
10. Simulation Models
11. Sensitivity Analysis
12. Probabilistic Techniques
13. Cost-Benefit Analysis
14. Export Base Models
15. Decision Analysis
16. Policy Capture
17. Life Cycle Analysis
18. Force Field Analysis

However, the conduct of analysis needs to be tailored to the type. The first thing to do is to choose the right tools which are most appropriate to the analysis and the technology characteristics. Thus, we have to set the criteria and figure out key aspects and factors for designing our research. Before discussing the methods, let me try to summarize the research topic, the outline, and the main research aims.

The existing literature offers several relevant insights about my research topic, but also has shortcomings within the context of technology assessment of an emerging socio-technological system of systems. Our research aims to offer technology assessment of VTOL Personal Air Vehicles (PAVs) or VTOL Mass Air Vehicles (MAVs) through a multi criteria analysis to examine potential benefit of an emerging technology option to supplement urban and regional transportation system and the feasibility of that system in a case study in Istanbul. In research, we will try to present a sample framework with effective research methods for evaluating economic, technological, social, and environmental aspects of a long term emerging socio-technological system of systems.

Limitations of the current ground and airline transportation systems, increasing congestions and poor block speed, combined with expanding population and demand for affordable mobility will

drive the development of future transportation technology and policy. An out of the box answer to the issue might be in the air. And there has been a long held belief that aviation would one day be capable of reaching an everyday impact in people's daily lives. In this century, aviation has the potential to enable expanded air accessibility for more in our society. A third wave of aeronautics could bring about great new capabilities for society that would bring aviation into a new age of being relevant in most people's daily lives. The ability to personalize air travel through the use of an on demand, highly distributed air transportation system will provide the degree of freedom and control.

VTOL PAVs or MAVs are envisioned as the next logical step in the natural progression in the history of disruptive transportation system innovations. As the auto improved quality of life and standards of living in the 20th century, PAVs or MAVs are envisioned to do likewise in the 21st century. Considering door to door block time, on demand PAVs or MAVs have the potential to achieve a daily mobility reach of 125 to 250 miles, providing another five to ten fold increase over the auto today. Imagine the last 100 years without the tenfold increase provided by the auto over the horse, and the constraint effect this would have had on the economy. While not solution to all travel, PAVs or MAVs would provide a new, better choice for midrange trip distances up to 500 miles where airlines and auto mobiles provide poor block speed service. Such air transportation systems/vehicles could also obviously be used for longer haul, more than 1000 miles, as are auto mobiles today. PAVs are defined shortly as self-operated aircraft, capable of use and affordable by a large portion of the general public. MAVs are defined shortly single pilot monitored, 10 to 25 seats air vehicles for public transportation. The goal of these vehicles is to provide a breakthrough in personal air mobility, through dramatic time savings and increased reach and a greatly improved quality of life. VTOL PAVs and MAVs offer the potential for a breakthrough in mobility, capacity, congestion, and quality of life through the development of an on demand aerial transportation system.

The research is also intended to provide a vision to serve as a decision aid to developers, policy makers and users, and to contribute to the public and policy opinion forming on the potential consequences of the introduction of emerging air transportation technologies as an answer to the existing transportation issues or as the next logical step in the natural progression. The main aims are:

- To analyse whether the potential benefit of VTOL Personal and Public Air Transportation System (PPATS) is enough to develop and to continue the efforts, and visualizing in a case study,

- To investigate whether anticipated technological progress can be expected to be strong enough to enable VTOL PAVs and MAVs, and to determine the necessary technologies in which a considerable progress will have to take place to enable,

- To understand success factors for social acceptability, and to discuss main challenges including technological, operational, regulatory, social and environmental,

- To discuss and present a framework with effective research methods for evaluating economic, technological, regulatory, social and environmental aspects of PPATS as a long term socio-technological system of systems involving emerging technologies while exploring the impact of the assumptions made in the previous works.

In short, aerospace engineers have come up with numerous concept vehicles since the first flight by the Wright Brothers. Nevertheless, the general public has not embraced any of them because the necessary technologies have not reached a readiness level to enable. However, with the results obtained lately from the research activities, revolutionary technologies and regulations are bringing us closer to a Personal or Mass Air Vehicle daily reality. When? The time line for this to occur is as much a function of the required technologies becoming available, as it is to the development of new regulations, vehicle and airspace concepts, and an aerospace community more willing to take risk due to greater potential rewards. The overall goal implies integrating technology areas with practical everyday transportation requirements to design a class of vehicle which will achieve the following goals:

- Vertical and extremely short take off and landing,
- Operation at block speeds markedly faster than current combinations of land and air transportation and increasing daily radius of action,
- Unit and operation cost comparable to current luxury cars and small general aviation aircraft,
- Reliability and acceptable noise,
- Excellent safety comparable with airlines,
- Ability to integrate with existing land and air transportation system.

As we stated above, it is well known that the research design is the master plan specifying the methods and procedures for collecting and analysing the needed information in a research study. Thus, the first step is to define the factors affecting research design. For example, an Office of Technology Assessment (OTA) study was about Advanced High-Speed Aircraft (1980), concerned particularly with U.S. support for continuing development of an "SST" (supersonic transport). Key aspects were that it was normative, technology-focused, national level, action-oriented, and targeted to diverse users. This study examined both what "would be" (extrapolative), and what "should be" (normative) implications. In our case, we tried to sum the factors affecting the research design below:

- Time horizon is Long term vision for 10-15 years later and an emerging air transportation system,
- A socio- technological system of systems in transportation area,
- Main stakeholders are: government, local municipalities, diverse users, industry, research institutions, service providers, and interest groups,
- The purpose and motivation of the research are prediction, action oriented and normative,
- Approach: both qualitative and quantitative,

- Time and place of data collection: up to 2017; USA, Europe, Turkey, national and global,
- Drivers are technology and innovations,
- Scope is a system of systems and multiple sub technologies,

Tools that can be used are: cost/benefit analysis, life cycle analysis, scenarios, sensitivity analysis, decision analysis, case study, subjective judgement, roadmap, interview, benefit visualization tool, GOTChA chart, Literature review, attending conferences and briefings. Here is the sample research method approach to research questions:

Is the potential benefit of VTOL PPATS enough to develop?

- Literature review
- Cost and benefit analysis, benefit visualization tool
- Interviews
- Case scenario (Visioning) for Istanbul

Can the anticipated technological progress be expected to be strong enough to enable VTOL PPATS?

- Literature review
- Technology roadmap
- Technology GOTChA Chart
- In depth Interviews

What are the success factors for social acceptability?

- Literature review
- Interviews and questionnaire
- Media reviews and forums on relevant websites
- Subjective judgement

Conclusion

Change is happening at an ever faster rate today, driven partly by technological changes leading to changes in all other areas of our lives, and by the increasing interdependence between countries and peoples today, as well as the decentralization of societies and institutions within countries (also furthered by information technologies to). New surprises impact us far faster, and more profoundly, than we might think. Today's global trends, uncertainties, and surprises have the potential to significantly change the way the world works tomorrow. Shaping the world we want to live in means being more aware of the future and seeking better approaches. In a such increasingly uncertain environment, planning uncertainties force policy and decision makers to foster future-oriented technology analyses (FTA). FTA can help us react on the likely directions of technologies, manage the risks involved and shape technological trajectories in order to improve the long term benefits to society. Technology foresight refers to a systematic process to identify future technology developments and their interactions with society and the environment for the purpose of guiding actions designed to produce a more desirable future. Foresight methodologies seek to gather data and make sense of it so that people can think in different and new ways about the future. That data might be collected from humans or from the analysis of documents and artefacts, or both. The data might be analysed using qualitative or quantitative techniques, or both. To be used in strategy processes, however, data needs to be analysed, interpreted and used in ways that make sense to the organisation.

There is no single set of methods used in all foresight activities. The methods used need to reflect the resources available and the objectives of the exercise. The choice of methods is critical, though it often appears to be based upon what is fashionable or which practitioners have experience in. The methods may be organised and interrelated in different ways. In other terms, the conduct of foresight analyses needs to be tailored to the type. The first thing to do is to choose the right methods which are most appropriate to the analysis and technology characteristics.

In our case, the key aspects are that it is long term vision for 10-15 years later, an emerging air transportation system, a socio- technological system of systems in transportation area, diverse users, action oriented, normative, both qualitative and quantitative, national and global. Drivers are technology and innovations, and scope is a system of systems and multiple sub technologies. The probably research tools that can be used are cost benefit analysis, life cycle analysis, scenarios, sensitivity analysis, decision analysis, case study (Visioning), subjective judgement, roadmap, interviews, benefit visualization tool, technology GOTChA chart, literature review, and attending conferences.

REFERENCES

Baumann, M. (2013), Prospective system analysis of stationary battery systems under the frame of Constructive Technology Assessment, Enterprise and Work Innovation Studies, 9, IET, 9-27

Blind, K. (2008), Regulatory Foresight: Methodologies and Selected Application, Technological Forecasting&Social Change, 75, pp.496-516.

Boavida, N. (2011), How composite indicators of innovation can influence technology policy decision?, IET Working Papers Series, WPS03/2011

Choi, M. (2014), Foresight and Future Strategies for S&T: A View from Korea, Korea Institute of S&T Evaluation and Planning (KISTEP).

Ciali, T., Coad, A. and Rafols, I. (2013), Quantitative Analysis of Technology Futures, Part I: Techniques, Contexts, and Organizations, Nesta Working Paper, No. 13/08.

Conway, M. (2007), Overview of Foresight Methodologies, Thinking Futures.

Decker, M. and Ladikas, M. (2004), Bridges Between Science, Society and Policy Technology Assessment, Methods and Impacts (Methodological Selection), EU-US Seminar, New Technology Foresight, Forecasting & Assessment Methods, Seville.

Gordon, T.J. And Glenn, J.C. (2004), Integration, Comparisons, and Frontier of Future Research Methods, EU-US Seminar, New Technology Foresight, Forecasting & Assessment Methods, Seville.

Jackson, M. (2013), Practical Foresight Guide, shaping Tomorrow.

Keenan, M. (2007), Combining Foresight Methods for Impacts, NISTEP 3rd International Conference on Foresight, Tokyo.

Keenan, M., Miles, I. and Koi-Ova, J. (2003), Handbook of Knowledge Society Foresight, European Foundation, Dublin, http://www.eurofound.eu.int/transversal/foresight.htm

Leigh, A. (2003), Thinking Ahead: Strategic Foresight and Government, Australian Journal of Public Administration, Vol.: 62, No: 2, pp. 3-10.

Makridakis, S. (1996), Forecasting: Its Role and Value for Planning and Strategy, International Journal of Forecasting, Vol.:12, Issue 6, pp.513-537.

Miles, I. (2007), Foresight Methods, UNIDO Regional Initiative on Technology Foresight, Gebze.

Moniz, A. (2005), Methods for Scenario Building: it`s importance for policy analysis, Munich Personal RePEc Archive, MPRA 7893.

Moniz, A. (2008), Assessing scenarios on the future of work, Enterprise and Work Innovation Studies, vol. 4(4), pages 91-106.

Moore, M.D. (2003), Personal Air Vehicles: A Rural/regional and Intra Urban On Demand Transportation system, Langley research Centre.

My Copter (2014), Project funded by the European Union, htpp://www.mycopter.eu

Paliokaité, A. (2010), Industry level foresight: Designing foresight methods for Lithuanian energy sector, Enterprise and Work Innovation Studies, 6, pp. 9 – 51

Popper, R. (2008), How are Foresight Methods Selected?, Foresight-The Journal of Future Studies, Strategic Thinking and Policies.

Popper, R. (2009), How are Foresight Methods Selected, Prest-Manchester Institute of Innovation Research.

Porter, A.L. (2004), Technology Futures Analysis: Toward Integration of the Field and New Methods, Technological Forecasting & Social Change, Vol.: 71, pp. 287-303.

Porter, A.L. (2010), Technology Foresight: Types and Methods, Int. J. Foresight and Innovation Policy, Vol. 6, pp. 36-45.

Pplane, Project, Radical and Novel Ideas for Personal Air Transport System, 2014, http://ec.europa.eu/research/transport/projects: www.pplane-project.org

Rohrbeck, R. and Bade, M. (2012), Environment Scanning, Future Research, Strategic Foresight and Organizational Future Orientation: A Review, Integration, and Future Research Directions, ISPIM Annual Conference, Barcelona.

Santos, C. Araújo, M. and Correia, N. (2013), Exploring Interrelationships Between Events to Identify Strategic Technological Competencies: A Combined Approach, World Academy of Science, Engineering and Technology, Vol.:7.

SATS Overview, (2002), Small Aircraft Transportation Office, NASA, htpp://sats.larc.nasa.gov/overview sats.html

Scapolo, F. and Miles, I. (2004), Eliciting Experts` Knowledge: A Comparison of Two Methods, EU-US Seminar, New Technology Foresight, Forecasting & Assessment Methods, Seville.

Schuckmann, S., Linz, M., Von der Gracht, H. and Darkow, I. (2011), Delphi-based Distruptive and Surprising Transformation Scenarios on the Future of Aviation, European Foresight Platform, Brief No:192.

Tegart, G. and Johnston, R. (2004), Some Advances in the Practice of Foresight, EU-US Seminar, New Technology Foresight, Forecasting & Assessment Methods, Seville.

Vishnevskiy, K. and Karasev, O. (2013), Foresight and Road mapping as Innovative Tools for Identifying the Future of New Materials, National Research University Higher School of Economics.

Zweck, A., Braun, A. and Rijkers-Defrasne, S. (2014), International Foresight of 2000s: Comparative Analysis, Foresight-Russia, Vol.: 8, No: 2, pp.6-15.